IN THE SPECIFICATION:

At page 1, prior to line 4, please insert new headings and text as follows:

Cross-Reference to Related Applications

This application is the U.S. National Stage of International Application Number PCT/FI2003/000948 filed December 12, 2003 pulished in English July 1, 2004 under International Publication Number WO 2004/055556 and which claims priority ~~under 35 USC §119~~ to Finnish Patent Application No. 20022199 filed on December 16, 2002.

Field of the Invention

The present invention relates to a diffractive grating element arranged on or embedded within a light-transmittive, preferably planar waveguiding substrate and arranged to interact with an incident light wave in order to couple the energy from said incident light wave into said substrate to form at least one diffracted light wave propagating within said substrate and corresponding to at least one selected diffraction order.~~according to the preamble of the appended claim 1??.~~

Background of the Invention

At page 2, please amend the paragraphs beginning on line 18 through line 31 as follows:

Virtual displays, which are kept close to the eye, can be monocular or biocular. One type of virtual ~~displays are~~display is, for example, a Head Up ~~Displays (HUDs)~~Display (HUD), where the imaging optics are located somewhat further away from the eye.

An important and well-known aspect in virtual display devices, as also in many other optical systems, is the exit pupil diameter of the system. The diameter and also

the location of the exit pupil are of considerable practical importance defining largely the overall usability of the virtual display device. In visual instruments, including the virtual displays, the observer's eye needs to be positioned at the ~~centre~~center of the exit pupil located behind the optical system in order to see the image with full field-of-view. In other words, the exit pupil is like a window, through which the virtual image can be seen.

On page 3, please add the following heading on line 3:

Summary of the Invention

At page 5, please amend the paragraph beginning on line 35 through page 6, line 2 as follows:

To attain these purposes, the diffractive grating element according to the invention is divided into at least two different grating regions each having different diffractive properties and arranged on opposite sides respect to a transition point to form a splitted grating element, where the diffractions generated by said at least two different grating regions are arranged to mutually compensate for the variation in the input angle of the incident light wave to the total diffraction efficiency of the at least one diffracted light wave propagating within said substrate. ~~primarily characterized in what will be presented in the characterizing part of the independent claim 1~~. The ~~dependent claims~~detailed description below describes ~~describe~~ further some preferred embodiments of the invention.

At page 6, please amend the paragraph beginning on line 23 as follows:

In other words, the diffractive grating element according to the invention is divided into at least two different grating regions each having different diffractive properties and arranged on opposite sides with respect to the transition point to form a splitted grating structure. The diffractions generated by said at least two different grating regions are arranged to mutually compensate for the variation in the input angle of the incident light wave to the total diffraction efficiency of the at least one diffracted light wave that is arranged to propagate within said substrate.

At page 7, please amend the paragraph beginning on line 13 as follows:

With the invention good image quality with high and even brightness over the whole exit pupil can be achieved in both monocular or biocular EPEs. One specific object of the invention is thus to allow the~~to~~ manufacture of virtual display devices with significantly larger exit pupil diameter than prior art solutions without degrading the image quality. Along with larger exit pupil diameters, also a significantly larger eye relief can be achieved.

At page 7, please add the following heading on line 25:

Brief Description of the Drawings

At page 9, please add the following heading on line 1:

Detailed Description of the Invention

At page 9, please amend the paragraph beginning on line 11 as follows:

Figure 6 illustrates schematically a preferred embodiment according to the invention. A grating profile with asymmetrical period profile, in this particular example with a blazed period profile, is splitted symmetrically with respect to a transition point TP into left BG_{left} and right BG_{right} sides to form a splitted grating element SG. The left BG_{left} and right BG_{right} sides of the grating are mirror images of each other with respect to said transition point TP. The transition point TP is arranged on the point where the optical axis A of the incoming beam passes through the grating surface.

At page 11, please amend the paragraphs beginning on line 12 through page 12, line 8 as follows:

In Eq.(2) k is a constant describing how much the beam shifts at a given angle. For example, it is needed that as the whole ~~the~~ beam shifts onto the left side at extreme angle θ_{max}, then k gets a maximum value of $0.5/\theta_{max.}$ In other cases k gets values smaller than that. If $k = 0$, then the beam is not shifted at all on the grating.

In the case, when the input angle $\theta=0$ then the input beam is located symmetrically with respect to the transition point TP, i.e. the first half of the beam is incident on BG_{left} and the second half of the beam is incident on BG_{right}. It is evident from Fig. 8 that thanks to the splitted grating structure according to the invention, the total diffraction efficiency η remains substantially constant independent of the input angle θ in a situation where the beam "shifts" along the splitted grating depending on the location of the image point on the imager surface.

Figure 12 describes schematically how a splitted grating element SG according to the invention can be utilized in a monocular EPE. In Fig. 12 the first interaction of the incident light wave (W) with the splitted grating element SG is arranged to take place substantially within a single grating region MBG_{right}. Here the splitted grating element SG comprises on the right side a grating surface MBG_{right} optimized to generate first order diffraction $R_{+1,right}$ towards right along substrate S. On the left side, the grating surface MBG_{left} is optimized to generate a second order diffraction $R_{+2,left}$ towards right along substrate S. The aforementioned construction provides effective "recirculation" of the $R_{-1,right}$ diffraction "leaking" undesirably from MBG_{right} towards left along substrate S. Namely, based on Bragg reflection grating surface MBG_{left} diffracts $R_{-1,right}$ back towards right as $R_{+2,left}$. It can be shown that this "recirculated" beam $R_{+2,left}$ is completely parallel with respect to the beam $R_{+1,right}$. Therefore, if the input angle θ of the beam incident to the right grating surface MBG_{right} changes, altering the ratio of $R_{-1,right}$ and $R_{+1,right}$ reflections and the amount of light "leaking" towards right along the substrate S, the splitted grating structure is capable of recirculating the light travelling in the direction opposite ~~direction~~ than that desired.

At page 12, please amend the paragraph beginning on line 22 as follows:

The preferred applications of the invention include different ~~type~~types of virtual display devices, where beam expansion in one or more directions is performed to extend the exit pupil of the display device. In such display devices the image source can be, for example, a sequential ~~colour~~color LCOS-device (Liquid Crystal On Silicon), an OLED-device (Organic Light Emitting Diode), a MEMS-device (MicroElectroMechanical System) or any other suitable microdisplay device operating in transmission, reflection or emission.

At page 14, please amend the paragraph beginning on line 12 as follows:

The invention may also used in other applications than virtual displays. In principle, the invention is suitable to be used in any application where optical beam expansion in one or more directions is required. Thus, the invention can be applied to different ~~type~~types of optical couplers or other light modulator devices as well.